UNIT 11 ANTI-NUTRITIONAL FACTORS, FOOD CONTAMINANTS AND TOXIC ELEMENTS

Structure

11.0 OBJECTIVES

After reading this unit, you should be able to:

- describe food contamination, factors contributing contamination and methods of prevention;
- list the anti-nutritional factors in food;
- discuss food born illness; and
- state deficiency diseases.

11.1 INTRODUCTION

Foods are exceedingly complex mixtures of chemicals substances. Apart from containing nutritionally important constituents, some foods also contain substances, which are harmful. The presence of nonnutritive constituents in foods represents potential health risks of different characters and magnitudes to persons consuming them. If such food is ingested, it can cause food poisoning and infection. Food poisoning could be caused by ingestion of foods containing certain chemicals, toxic plants or animals, toxins produced by bacteria and ingestion of animal parasites. Pathogenic microorganisms may enter foods through poor handling and grow in it. When such contaminated

food is ingested, it could cause food infections. Hence, food safety should be a major concern of processor for the public health.

11.2 ANTI-NUTRITIONAL FACTORS

11.2.1 Anti-Nutritional Factors in Plant Foods

Plants are capable of synthesizing a multitude of chemical that cause toxic reaction when consumed. Pulses contain a number of toxic factors, such as protease inhibitors, lathyrogens and favism agents, cyanogens, haemagglutinins and saponins. Some of these toxins are also present in other foods, e.g., protease inhibitors in cereals and potatoes. Solanine, ordinarily the green parts of the potato are removed with the peel, is a toxicant in potatoes. Goitrogens (cause thyroid enlargement) are present in cabbage and related species, rapeseed and mustard. Some varieties of mushroom (e.g. Amanita) are poisonous. Oxalic acid present in spinach, beet etc may cause oxalic poisoning. Soybean contains trypsin inhibitor that affects protein metabolism. Cassava and Lima beans contain linmarin, a toxic glycoside. Lathyrism is a neurological disease caused by the ingestion of *Lathyrus sativus* (khesari dhal) for a period of 6 months or more. Favism agents in fava beans, gossypol in cottonseed are also potent toxic substances.

The active flavoring principles present in some spices may have toxic effects if consumed habitually over long periods or in excessive amounts. Active principles in some of the foods are allyl isothiocyanate in mustard, capsaicin in chillies, myristicin in nutmeg and mace, etc.

11.2.2 Toxicants in Animal Foods

The ingestion of shellfish (clams, mussels) results in paralytic shellfish poisoning. Saxitoxin, an extremely toxic metabolite, is p roduced from the plankton. The toxin resists ordinary cooking procedures. Sea food poisoning, for examples, ciguatera poisoning, moray eel poisoning, scombroid poisoning, puffer fish poisoning, cephalopod poisoning, is mostly prevalent in the areas where marine organisms constitute about 10 per cent of the diet.

11.3 CONTAMINATION OF FOOD BY MICROORGANISM, PATHOGENS

A large number of careless practices cause contamination of food with potentially pathogenic microorganisms. The more common ones are unhygienic practices of food handling, personnel handling food suffer from communicable diseases, cross contamination of food, contaminated water and containers, soil adhering to foods, insects, droppings of rodents.

Contamination by Bacteria

Certain bacteria release poisons known as toxins. Some toxins produced by *Clostridium botulinum* are often cause death of persons consuming food contaminated with this organism. The bacteria such as Staphylococcus aureus and Bacillus cereus produce toxins in food during multiplication or sporulation. Although cooking may destroy these bacteria but the toxin is unaffected and can still cause the problems if food is eaten. Endotoxin are

generally produced by bacteria such as *Salmonella* in the intestines of persons consuming food contaminated with such organisms.

Contamination by Moulds

Almost any food can be invaded by mould growth. Moulds cause various degree of visible deterioration and decomposition of foods. Moulds may produce abnormal flavours and odours due to fermentative, lipolytic, and proteolytic changes caused by enzymatic reactions with carbohydrates, fats, and proteins, respectively in foods.

Contamination by Yeasts

Food that is highly contaminated with yeasts will frequently have a fruity odour. Yeasts can grow in a product with low sugar concentration. Most of them do not develop in solutions containing more than 66% sugar or 0.5% acetic acid. Boiling destroys the yeasts cells and spores completely. Foods liable to be spoiled by yeasts are fruit juices, syrups, molasses, honey, jams and jellies.

Contamination by Viruses

Viruses are transmitted to food by workers who are carriers. An infected food handler can excrete the organism through the faeces and respiratory tract infection. The inability of host cells to perform their normal function causes illness due to viral infection.

Check Your Progress Exercise 1

Note: a) Use the space below for your answer.
b) Compare your answers with those given at the end of the unit.

1. 'Non-nutritive constituents of food can create potential health risks', justify.

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2. Write some of the important anti-nutritional substances present in vegetables.

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3. Define endotoxins. List the factors responsible for food contamination.

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11.4 FOOD INTOXICANTS

The undesirable constituents that affect the safety of foods include toxicants naturally occurring in foods, toxins resulting from microbial growth, environmental contaminants such as processing and accidental contaminants and chemical contaminants.

Naturally occurring toxicants in plant and animal foods

Foods contain thousands of compounds that are potentially toxic. For example protease inhibitors, lathyrogens, favism agents, cyanogens, haemagglutinins and saponins in pulses, solanine in potatoes, goitrogens in cabbage, rapeseed, etc., trypsin inhibitor in soybean, beta oxalyl amino alanine in khesari dhal, linmarin in cassava and lima beans, Favism agents in fava beans, gossypol in cottonseed are potent toxic substances. Some spices contain active principals (e.g., allyl isothiocyanate in mustard, etc.) may have toxic effects. Paralytic shellfish poisoning from oysters, calms, mussels, and scallops has caused many fatal illness. Saxitoxin, an extremely toxic metabolite, is produced from the plankton.

Microbial Toxins

Microorganisms promote desirable changes in foods under controlled conditions. However, they also cause harmful effect and are involved in most cases of food poisoning.

Bacterial food intoxication: Staphylococcal poisoning occurs abruptly after ingestion of food containing the enterotoxin, produced by staphylococci present in semisolid foods. Foods such as corn, peas, meat, fish are likely to be contaminated with the spore of Clostridium botulinum. They act on nervous system and are potent poisons and cause a disease known as botulism. The food infected with Bacillus cereus, if consumed is also harmful.

Some species of fungi such as Aspergillus flavus, Aspaergillus parasiticus (produced aflatoxins) Claviceps purpurea, Fusarium species produce toxins in foods infected with them and make the foods unfit for consumption.

Environmental Contaminants

These include residues that become part of food as a result of processing, handling and distribution of food. For examples, ethylene oxide used as fumigants to sterile some food reacts with inorganic chlorides to form ethylene

chlorohydrin, which is toxic. During smoking of meat and fish for preservation and flavouring, these foods get contaminated with polycyclic aromatic hydrocarbons (e.g. benzopyrine), many of which are carcinogenic.

Metals, find their way into foods through air, water, soil, industrial pollution and many other routes, when present beyond the permissible limit, are toxic. Mercury, cadmium, lead, tin, etc. are the toxic metals present in foods.

Other contaminants from food processing such as lubricants, boiling water additives, packaging material, inside coating of the packaging materials, etc. may contaminate the food and their products and make them unfit for consumption.

11.5 MYCOTOXINS

Mycotoxins are toxic metabolites produced by various moulds when they grow on agricultural products before or after harvest, and during transportation or storage. Some moulds such as Aspergillus species and Penicillium species can invade grains after harvest and produce mycotoxins, while others such as Fusarium species, infect grains and produce mycotoxins before harvest. Mycotoxins remain in the food long after the mould producing them has died and can therefore, be present in foods that are not visibly mouldy. Further many mycotoxins, but not all, are stable and survive the usual conditions of cooking or processing.

Mycotoxins are undesirable because of their adverse effect on both human and animal health. Many mycotoxins have been found to occur naturally in a large number of commodities, but only few of these are widely accepted as causing significant food safety risks. Food grains, especially rye, bajra, sorghum and wheat have a tendency to get infected with the ergot fungus, Claviceps purpurea. Consumption of ergot infected grains leads to ergotism. Mycotoxins produced by certain moulds, Aspergillus flavus and Aspergillus parasiticus are known as aflatoxins. These fungi develop in many foods particularly in maize, sorghum, groundnut, etc. under improper storage conditions and produce aflatoxins of which B_1 and G_1 are the most potent hepatotoxins, in addition to being carcinogenic.

Moisture content of foods above 16 per cent and temperatures ranging from 11 to 37^0 C favour toxin formation. Fungal contamination can be prevented by proper storage after drying the grains to 10 per cent moisture level.

11.6 FOOD POISONING AND FOOD INFECTIONS

11.6.1 Food Poisoning

Food poisoning is an acute gastro-enteritis or any other disorder caused by ingestion of food contaminated with either living bacteria or their toxins or inorganic chemicals and poisonous plant and animal foods.

i) Food poisoning by microorganisms

Botulism is a severe form of food poisoning caused by ingestion of inadequately cooked canned food (beans, peas, etc.) contaminated with bacteria; Clostridium botulinum. The symptoms of botulism occur 18 to 36

hours after ingestion of contaminated food and begin in gastrointestinal tract. The principal hazard is the effect on the nervous system. Death may occur as a result of respiratory paralysis and cardiac failure.

Staphylococcal food poisoning is the most common form of food poisoning which occurs after ingestion of food contaminated with Staphylococcus aureus. Staphylococcus contamination of food may either be from human or animal sources. Some strains of *Staphylococcus aureus* can produce an enterotoxin. Staphylococcal food poisoning can be characterized by salivation, nausea, vomiting, abdominal cramps and diarrhoea. Pasteurization kills all the Staphylococci that may be present in foods but toxins may not be destroyed by pasteurization or ordinary boiling.

Salmonella food poisoning caused by the ingestion of foods particularly commercially prepared animal foods, contaminated with S. typhimurium, S. cholera-suis and S. enteritis besides many others. Salmonellosis may be characterized by enteric fever, gastro-enteritis.

Clostridium perfringens food poisoning: C. perfringens has been found in faeces, soil, water and air. The majority of this type of poisoning has been associated with ingestion of fresh or frozen meat, meat preparations and poultry. The common symptoms of this poisoning are diarrhoea, abdominal cramps and fever, occurring 8 to 24 hours after consumption of the food. The bacteria are destroyed by ordinary cooking temperature but spores survive at this temperature and need thorough cooking.

Cereus food poisoning caused by Bacillus cereus and their toxin, found in raw, dried and processed foods. The spores can survive at cooking temperature and multiply rapidly when food is held at room temperatures. The poisoning is characterized by gastro-intestinal tract symptoms.

Some of the species of fungi such as *Aspergillus flavus*, *Aspergillus parasiticus*, *Claviceps purpurea*, *Fusarium* species produced toxins in foods and make those foods unfit for human consumption.

ii) Contaminants arising from processing, accidental contaminants and chemicals

These include residues that become part of food as a result of processing, handling and distribution of food, e.g., fumigants. Ethylene oxide is a commonly used fumigant. Ethylene oxide reacts with inorganic chlorides to form ethylene chlorohydrin, which is toxic. Solvents like trichloroethylene, used for extraction of oil from oilseeds reacts with the substances and produce a toxic product.

During smoking of meat and fish for preservation and flavouring, these foods get contaminated with polycyclic aromatic hydrocarbons (e.g. benzopyrine), many of which are carcinogenic.

Metals find their way into foods through air, water, soil, industrial pollution and many other routes. Metals (mercury, lead, tin, aluminum, etc.) beyond the permissible limits are toxic.

Poisoning by chemicals is not very common. Poisonous chemicals like arsenic, cadmium, antimony can enter foods through improperly coated

utensils. Insecticide and pesticides (malathion etc.) residues can also cause food poisoning if contaminated food is consumed without washing.

iii) Poisonous plants and animals

Certain varieties of mushrooms are very poisonous and could be fatal if consumed. Snakeroot poisoning could result from drinking milk from cows that have fed on this weed. Seafood such as mussels and clams sometimes contain a poisonous alkaloid. Death camas contains a poisonous alkaloid that decrease blood pressure if consumed. Bush tea contains toxic factors, which are known to cause occlusive disease of the liver, often leading cirrhosis. Pulses contain a number of toxic substances such as protease inhibitors, lathyrogens and favism agents, cyanogens, haemagglutinins and saponins. Saponins goitrogens, oxalic acid present in some foods can cause poisoning if consumed in large quantities. Gossypol is a toxicant found in cottonseed. Sea foods poisoning, toxicants present in certain spices and flavours. Toxic substances found in certain food fats cause food poisoning when consumed in large amounts.

11.6.2 Food Infections

Pathogenic microorganisms and parasites may enter foods through poor handling and grow in it. Food containing a large number of pathogens if ingested can cause food infections. Food borne infections are especially prevalent in communities with inadequate facilities for storing foods and insanitary water supplies and lavatories. The principal types of infectious organisms that may cause diseases are: bacteria, moulds and viruses.

Bacterial food infections result from the ingestion of large amount of viable bacteria, which multiply inside the host and cause infections. Some of the common infectious diseases caused by bacteria are:

- Cholera is one of the most acute and violent infections, characterized by fever, severe diarrhoea, abdominal cramps, vomiting, intense thirst followed by collapse. Cholera spreads from infected person and faecal-contaminated food and water.

- *Bacillus cereus* infection characterized by severe vomiting 1 hour after ingestion or diarrhoea later.

- Escherichia coli food infection is spread by contaminated food and water. It is characterized by gastroenteritis and most common infection in infants.

- Salmonellosis is characterized by diarrhoea, abdominal cramps and vomiting, which usually lasts for 2 to 3 days. Salmonella bacteria grow rapidly in cooked eggs, meat, custards and salads, which have been left at room temperature for several hours.

Some other bacterial infections, which are caused by ingestion of contaminated food, are tuberculosis and typhoid.

Many diarrhoeal diseases, viral hepatitis, gastroenteritis, etc. are transmitted primarily by faecal-oral route. Faecal oral transmission may be water born, food born, or direct transmission, which implies an array of other faecal-oral routs such as via fingers, or fomites, or dirt.

Parasitic Infestation of Foods

Many protozoa, helminthes (worms) gain admission to the body by means of food and cause injury to the intestinal lining and sometimes other tissues. Amoebiasis is a common infection of gastrointestinal tract, caused by potentially pathogenic strain of Entamoeba histolytica. The helminthes that frequently invade the intestinal tract include nematodes (round worms), cestodes (tapeworms), and trematodes (liver, intestinal, and lungs flukes). Tricinosis, one of the most serious infestation results from ingestion of raw or partially cooked pork infected with Trichinella spiralis, a very minute roundworm. Trichinella is destroyed by cooking pork, until no trace of pink remains. Foods act as a carrier for the parasites but none of these organisms grow in the food as such. Usually such contamination occurs due to poor handling of food and preparation.

11.7 FOOD BORN DISEASES

Food borne disease is caused by agents that enter the body through the ingestion of food. Food borne diseases may be classified as:

A) Food Borne Intoxications

i) Due to naturally occurring toxins in some foods, e.g., lathyrism, endemic ascites, etc.

ii) Due to toxins produced by certain bacteria, e.g., botulism, staphylococcal food poisoning.

iii) Due to toxins produced by some fungi e.g., aflatoxins, ergot, fusarium toxins, etc.

iv) Food borne chemical poisoning

- Heavy metals, e.g., mercury (in fish), cadmium (in certain shellfish), and lead (in canned food)
- Oils, petroleum derivatives and solvents
- Migrant chemicals from packaging materials
- Pesticide residues (DDT, BHC)

B) Food borne infections

i) *Bacterial infections:* typhoid, cholera, salmonellosis, shigellosis, etc.

ii) *Viral infection:* viral hepatitis, gastroenteritis

iii) *Parasitic infestations:* ascariasis, amoebiasis, trichinosis, etc.

(Details about food borne diseases was covered under food toxins, food poisoning and food infections)

Check Your Progress Exercise 2

Note: a) Use the space below for your answer.
b) Compare your answers with those given at the end of the unit.

1. What is food poisoning? Explain with the help of examples.

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2. What do you understand by food borne diseases? Write the name of some common food borne infections.

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3. What are mycotoxins? Write a brief note on aflatoxins.

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4. What are different environmental contaminants that make the food unfit for consumption?

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11.8 METHODS OF PREVENTING FOOD CONTAMINATION

Contamination can be reduced through effective housekeeping and sanitation, protection of food during storage, proper disposal of garbage and litter, and protection against contact with toxic substances.

The Environment

Only cleaned hands should touch food during handling and processing. A processed product should be kept covered to prevent the entry of dust or other things. If the nature of food does not permit this kind of protection; it should be placed in an enclosed, dust free cabinet at appropriate temperature. Equipment and utensils for food processing, packaging, preparation, and service should be cleaned and sanitized between uses.

Storage

Storage facilities should provide adequate space with appropriate control and protection against dust, insects, rodents, and other extraneous matter. Organized storage layouts can reduce contamination and facilitate cleaning. In addition storage area floors shelves and/ or racks should be cleaned regularly. Waste materials should not be accumulated in the food storage area.

Litter and Garbage

Waste and refused materials (used packaging materials, containers and waste products) should be placed in appropriate containers for disposal. These receptacles should be seamless, with close fitting lids. Plastic liners are inexpensive and provide added protection. All receptacles should be washed and disinfected regularly. Containers kept in food processing and food preparation areas should not be used for garbage or litter, other than that produced in those areas.

Toxic Substances

Poisons and toxic chemicals should not be stored near food products. In fact, only chemicals (well labelled) required for cleaning should be stored in the same premises. Only cleaning compounds, supplies, utensils, and equipment approved by regulatory or other agencies should be used in food handling, processing, and preparation.

11.9 DEFICIENCY: PROTEIN, VITAMIN AND MINERAL – CONSEQUENCES AND CORRECTIVE MEASURES

As a consequence of dietary deficiency, several nutritional problems are encountered namely (i) PEM (ii) vitamin A deficiency, (iii) iron deficiency anaemia, (iv) iodine deficiency, (v) vitamin B-complex deficiencies.

Protein Deficiency

Protein energy malnutrition (PEM) is the name given to various degree of nutritional disorders caused by inadequate quantities of protein and energy in the diet of young children. This leads to various degree of growth retardation. When growth retardation is severe, functional deficiencies, like resistance to

infection, poor intellectual development and body may have wasted away. Kwashiorkor and marasmus are two clinical forms of PEM at opposite poles of a single continuum. Kwashiorkor (growth failure, oedema, diarrhoea, fatty liver, dermatitis and other symptoms) occurs when there is a lack of protein in the diet but calories or energy in the form of carbohydrates is available in sufficient quantity. However, when both protein and energy are insufficient, over prolonged periods, a condition known as marasmus (growth failure, wasting of muscles, and dry and atropic skin and other symptoms) occurs in children. Both kwashiorkor and marasmus can be complicated with other infections due to intestinal parasites and bacteria.

The dietary management along with medical treatment for infection, if any is necessary for rapid recovery of the child with PEM. The diet should be rich in easily digestible proteins (4-5 g/ kg normal body weight of the child) of high nutritive quality (from milk and milk product, legumes, sprouts etc.), calories (140 Kcal/ kg body weight) and all dietary essentials (vitamin A and iron supplementation).

Vitamin Deficiencies

Vitamin A deficiency is a major nutritional problem in young children leading to blindness. Night blindness (inability to see in dim light), Conjuctival xerosis (conjuctiva becomes dry and non-wettable, appears muddy and wrinkled), Bitot's spot (triangular, pearly-white or yellowish, foamy spots on the bulbar conjuctiva on either side of the cornea), corneal xesosis (cornea appears dull, dry, non wettable and eventually opaque) and keratomalacia (cornea may become soft and burst open) are important deficiency states due to vitamin A deficiency. The person with vitamin A deficiency should be given well balanced diet including green leafy vegetables and yellow and orange fruits in sufficient quantities with the vitamin A supplementation.

Vitamin D deficiency causes Rickets in children (characterized by enlarged joint, bowed legs, knocked knees, bulging forehead, pot belly, delayed eruption of temporary teeth, muscular hypotonia etc.) and Osteomalacia in adults, in which bones soften, become distorted, and fracture easily. The subjects (children or adults) should be given a well balanced diet containing plenty of milk, ragi, and green leafy vegetables along with calcium and vitamin D supplementation.

Vitamin C deficiency produces the disease scurvy characterized by swollen and inflamed gums, loss of weight, anaemia, poor wound healing, pain in joint and muscles. Severe form of scurvy is fatal. In addition to well balanced diets with sufficient amount of locally available fruits and germinated legumes, vitamin C supplementation is important.

Vitamin B-complex deficiencies commonly encountered are riboflavin deficiency leading to angular stomatitis, glossitis and cheilosis; thiamine deficiency leading beri-beri and niacin deficiency (Pellagra). Thiamine deficiency is prevalent in areas where polished rice is the staple food. Inclusion of under milled, or parboiled rice, whole wheat and wheat products, nuts, legumes could help to remove thiamine deficiency. Use of milk and milk products, eggs, green leafy vegetables could prevent riboflavin deficiency. Groundnuts are rich in niacin. Use of combination of cereals, pulses and inclusion of groundnuts would help in preventing vitamin B-complex deficiency.

Mineral Deficiencies

Nutritional aneamia and iodine deficiency are the major public health problems due to mineral deficiencies. Aneamia affects all segments of population in general and children, women and pregnant women in particular. Anaemia may be due to deficiency of iron, or folic acid or vitamin B_{12}. The incidence of anaemia can be reduced by inclusion of leafy vegetables, pulses, whole grains and vitamin C rich seasonal fruits in diet. Since change in dietary habits is a slow process, some interim public health measures have been taken to reduce the incidence of anaemia. These include distribution of tablets containing iron and folic acid at primary health centers. In order to combat and prevent iron deficiency anaemia, fortification of a universally consumed dietary item with iron can be one of the most effective methods.

The Iodine deficiency in man leads to a number of disorders, which include goiter, mental retardation, cretinism, myxoedema, and neuropsychic retardation. The simplest way of eradicating iodine deficiency is by consumption of iodized salt.

11.10 METHODS OF NUTRIENT RETENTION DURING PROCESSING AND STORAGE

Using food preparation methods maximizing nutrient retention is most important to maintain the quality of foods. The processing methods generally used in food preparation; also affect the nutritive quality of various foodstuffs.

i) Nutrients retention during milling

Milling of cereals like paddy to get rice causes considerable loss of vitamins, minerals and proteins. Parboiling of paddy can significantly reduce the nutritional losses during milling of paddy. During parboiling of paddy, B-vitamins present in the bran gets fixed to the grain and hence not removed during milling. Washing of rice before cooking in limited amounts of water also reduce the loss of thiamine due to leaching.

Nutritional loss also occurs during dehulling of pulses. The dehulling losses, in terms of broken and powder fractions can be reduced by following suitable pre-milling treatment (heat treatment or oil treatment etc.) and conditioning of legume seeds before dehulling.

ii) Prevent nutrients from leaching

Water leaches out some vitamins and minerals from the foods. Presoaking of food grains has negligible effect on nutrients such as proteins and fats but digestibility of starch improves. If soaking water discarded, reduction in some nutrients such as minerals and B-complex vitamins will occur. Rice should not be washed for longer time to avoid the loss of thiamine and niacin. The nutrients are also lost if water in which vegetables are cooked, discarded. Vegetables and fruits should be washed before cutting to avoid the leaching of nutrients in washing water.

iii) Avoid excessive heat treatment

Excessive heat destroys heat sensitive vitamins and decreases the protein quality. Preparing food in smallest amount of water at optimum temperature for the shortest time does least nutritional damage. Reheating

of food products will add to the loss of nutrients. If required microwave heating for a few seconds may serve the purpose.

iv) Save foods from exposure to oxygen and light

Oxygen in the air and light decreases the amount of vitamins A, B_{12}, C, D, and E, folic acid, and thiamine in foods. Light also decrease the vitamin B_6 and riboflavin. Unsaturated fatty acids are unstable in the presence of air. Packaging of food material is an important measure to protect the foods from losses due to exposure to air and light.

v) Avoid wide changes in pH

pH is important because vitamin A and K and folic acid are unstable in an acidic environment, whereas, vitamin C, D, and K, pantothenic acid, riboflavin, and thiamine are unstable in an alkaline medium.

vi) Minimize trimming and peeling

Trimming and peeling should be kept to a minimum. The skin of fruits has valuable amounts of fibre and vitamin C. The outer leaves of vegetables are good sources of some vitamins and minerals.

vii) Careful handling of perishable foods

Removal of diseased, damaged and scratched fruits and vegetables during grading and post harvest treatment are highly useful in reducing the losses.

viii) Avoid the use of sodium bicarbonate to cooking water

Addition of sodium bicarbonate to hasten the cooking of dhal or to retain the colour of vegetables causes heavy loss of thiamin and vitamin C, hence should be avoided.

ix) Moisture content of food

For best storage and to prevent nutritional losses in food grains and oilseeds, these should be thoroughly cleaned, graded and dried to bring down the moisture content below 10 per cent.

x) Packaging

Packaging of foods particularly fruit and vegetables minimize physiological and biochemical changes. Packaging in modified atmospheric (MA) condition reduce the losses of vital nutrients during storage.

xi) Storage at low temperature

The loss of moisture is reduced by storing the vegetables in an atmosphere of high relative humidity at low temperature. Canned foods retain higher levels of vitamin C and thiamine if stored at low temperature. Roots and tubers can be stored at a temperature between 3 to 10^0C to keep sprouting minimum. Ageing of leafy and other vegetables, and fruits can be retarded by low temperature storage.

11.11 FOOD ANALYSIS, RESIDUE ANALYSIS

11.11.1 Food Analysis

Food analysis enables us to know the composition of fresh food and food products. A complete analysis of fruits and vegetable products includes determination of water content, protein, fat, nitrogen-free extract, fibre and ash. Each group is not made up exclusively of allied chemical substances, but rather of substances that happen to have one or more properties in common. The methods employed for the determination of these six constituents involves precipitation, colour comparison, or centrifuging or titration.

The water is determined by drying at $\leq 120^0$ C (depending on the commodity) in ovens for a certain period; the protein by calculation from the total nitrogen; total nitrogen by digestion (of sample), distillation and titration using some chemicals; the fat by ether extraction; the fibre by removal of all acid and alkali soluble constituents, and weighing the residue; the ash by incineration.

11.11.2 Residue Analysis

Residue analysis is concerned with the safety of food for human consumption. Whether applied to analysis of any kind of residue, all residue analysis has its ultimate aim; the capacity to identify food as safe or unsafe for human consumption. Residues analyses on food are undertaken for a very wide range of purposes. In the development of agrochemicals and veterinary drugs, for example, detailed studies on persistence of drugs in crops and/ or animal tissues post-treatment are required. In addition, studies on the metabolism of these chemicals require extensive residue analysis. For chemicals used in farming or occurring as contaminants from the environment and/ or industrial processes, residue analysis is undertaken as part of the monitoring programmes of regulatory agencies to ensure that residues, where they occur in foods, are at levels with respect to the established maximum residue limits (MRLs). In the case of prohibited substances, residue testing is designed to monitor compliance with the regulations. Generalized format for residue analysis is shown in Figure 11.1.

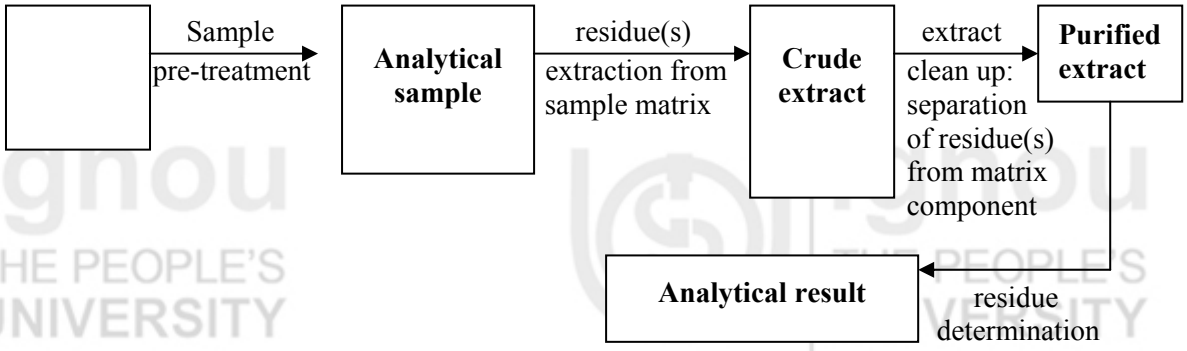

Figure 11.1: Generalized format for residue analysis

Within the spectrum of residue analysis methods, including screening, quantitative and confirmatory methods, there are methods ranging from single-step to multi-step methods. Example of the former are the four plate test for inhibitory substances in meat, for which all pre-determination steps are combined into a single step of cutting disc of frozen meat from the sample, placing them on prepared agar plates and incubating overnight, and a sol

particle immunoassay (SPIA) test for sulphamethazine in urine, for which all pre-treatment steps are eliminated and the sample is applied directly to the test device. At other extreme are complicated methods with multiple steps such as methods for confirming the presence of residues of anabolic agents in tissues or bile. These methods involved weighing and homogenizing of sample, pH adjustment of the homogenate, overnight incubation with glucuronidase/ sulphatase to hydrolyse conjugates, extraction of residues directly with solvent or on a diatomaceous earth column, liquid/ liquid partitioning steps and multiple column chromatography or solid phase extraction (SPE) steps to remove co-eluting interferences, multiple evaporation of solvents, derivatisation of the residues and clean-up of the derivatised extracts, prior to determination by gas chromatography-mass spectrometry. In between these extremes lie the majority of residue methods but, in general, the extent of quantification and confirmation and the nature of the sample (solid or liquid) determine whether simple or more complex methods are used.

Table 11.1: Categories of chemical that can arise as residue in food

Category	Examples
a) Natural	
Normal components in food	Phytoestrogens, glycoalkaloids, erucic acid
Natural contaminants in food	Mycotoxins, phycotoxins (aquatic biotoxins)
b) Synthetic	
– Agricultural chemicals	– Pesticides, fertilizers
– Veterinary drugs	– Antibiotics, anthelmintics, growth promoters
– Food additives	– Preservatives, antioxidants
– Chemicals from packaging	– Vinyl monomers, oligomers
– Food processing chemicals	– Nitrosamines, polycyclic aromatic hydrocarbons (PAHs)
– Environmental contaminants	– Dioxins, polychlorinated biphenyls (PCBs)

Check Your Progress Exercise 3

Note: a) Use the space below for your answer.
b) Compare your answers with those given at the end of the unit.

1. What is malnutrition? What is the most common form of under-nutrition prevalent amongst vulnerable group?

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2. Discuss different methods that can reduce the nutrients losses.

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11.12 LET US SUM UP

Some foods contain toxic constituents, if consumed in sufficient quantities may prove to be hazardous. The hazardous substances include toxicants naturally occurring in foods, toxins produced by microorganisms, and environmental contaminants. The microorganisms most common to food are bacteria and fungi; get their entry in food as a result of unhygienic practices during food handling, processing and storage. Bacterial contamination is the most significant as it may result in food poisoning. Botulism is the most fatal and Staphylococcal food poisoning is the most common form of food poisoning due to bacterial contamination of food. Contamination can be reduced by safe food handling practices, processing under sanitary conditions, protecting food during storage, proper disposal of waste materials, and protection against contact with toxic substances. These practices will not only reduce the contamination from toxicants but also the nutritional losses and thus prevent food losses and nutritional deficiencies amongst population.

11.13 KEY WORDS

Aneamia : is a condition characterized by reduction in red blood cells, packed cell volume or circulating haemoglobin, resulting in pallor appearance and shortness of breath especially on exertion.

Contamination : entry of undesirable organisms in some material or object.

Endotoxins : toxins produced inside the cell wall and can only permeate the food or the body when the organism is killed.

Exotoxins : toxic substances produced by bacteria which diffuse out of the cells and stimulate the production of antibodies.

Malnutrition : is a condition result from an inadequate (under nutrition) or excessive intake of one or more nutrients (over nutrition) or some defect in metabolism, which prevents the body from using the nutrients properly, e.g., PEM, Vitamin A deficiency, obesity.

Pathogens : disease causing microorganisms.

Toxicity : is the capacity of a substance when tested by itself to harm living organisms.

11.14 ANSWER TO CHECK YOUR PROGRESS EXERCISES

Check Your Progress Exercise 1

Your answer should include the following points:

1. Foods contain some anti-nutritional factors.

   Excess consumption over a long period can cause health problems, e.g. lathyrism. See sub-sec. 11.2.

2. Protease inhibitor and solanine in potatoes, goitrogens, oxalic acid. See sub-sec. 11.2

3. Some bacteria produced toxins inside the cell wall.

   Unhygienic practices, cross contamination of food, contaminated water and containers, soil adhering to foods, insects, droppings of rodents, etc. See Sub-sec. 11.3.

Check Your Progress Exercise 2

Your answer should include the following points:

1. Ingestion of contaminated food may result in food poisoning.

   Botulism, Staphylococcal food poisoning, Salmonellosis, Clostridium perfringens food poisoning, Cereus food poisoning, lathyrism. See sub-sec. 11.6 and 11.7.

2. Food may be contaminated by pathogenic organisms.

   Diseases caused by agents that enter the body through ingestion of contaminated food.

   Typhoid, cholera, salmonellosis, hepatitis, amoebiasis, etc. See sub-sec.11.6 and 11.7.

3. Moulds grow on agricultural products and produced toxic metabolites.

   Bacteria- Aspergillus flavus and Aspergillus parasiticus produce aflatoxins. See sub-sec. 11.5.

4. Residues in foods from fumigants, presence of metals beyond the permissible limits, chemical residues See sub-sec. 11.6.1.

Check Your Progress Exercise 3

Your answer should include the following points:

1. Undernutrition, over nutrition.

   PEM. See sub-sec. 11.10.

2. Parboiling, optimum heat treatment, save from exposure to oxygen and light, avoid wide changes in pH, careful handling of perishable foods, minimum trimming and peeling, storage at Low temperature. See sub-sec. 11.11.

11.15 SOME USEFUL BOOKS

1. Marriott Norman G. (1999) Principles of Food Sanitation (4th Edition), Aspen Publishers, Inc., Gaithersburg, Maryland.

2. Park, K. (1994) Textbook of Preventive and Social Medicine (14th Edition), Banarasi Das Bhanot Publishers, Jabalpur.

3. Ranganna, S. (1991) Handbook of Analysis and Quality Control for Fruit and Vegetable Products (2nd Edition), Tata McGraw-Hill Publishing Company Limited, New Delhi.